Experimental technique for measurement of (n,xn) double-differential cross sections for incident neutron energies above 100 MeV

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In progress of intermediate energy proton-accelerator technology, a highly intense neutron source by spallation reactions becomes usable for scientific researches and industrial developments. Accelerator-Driven-Systems (ADS) for energy production and long-lived nuclear-waste transmutation have been proposed. The research and development thereof have raised the practical need for neutron nuclear reaction data such as neutron-incident neutron production (n,xn) double differential cross sections (DDX) in the intermediate energy region. Some experimental data of (n,xn) DDX were reported for incident neutron energies above 20 MeV. These measurements were conducted by using the monoenergetic neutron beam. However, the experimental data have never been obtained above 100 MeV because of the lack of the monoenergetic neutron field.

The experimental technique for measurement of (n,xn) DDX for incident neutron energies above 100 MeV for a natural lead has been developed with continuous-energy neutrons up to 400 MeV. Incident neutrons were produced in the spallation reaction by the 800-MeV proton beam at Los Alamos Neutron Science Center (LANSCE) in Los Alamos National Laboratory (LANL). The energies of incident neutrons were determined by the time-of-flight method. The neutron flux was monitored by a fission ionization chamber. Emitted neutrons were detected by the recoil proton method. The radiator was a 20-mm thick polyethylene disk. We also performed measurements with a carbon disk to eliminate the contribution of carbon reaction. A phoswich detector consisting of a NaI(Tl) and NE102A plastic scintillators was used for detecting recoil protons to detect the recoil protons as full stop events. A veto counter was set in front of the radiator to eliminate the charged particles from the sample. The veto counter was 10-mm thick NE102A plastic scintillator. The dE counter was located between the radiator and the phoswich detector to identify the charged particles produced in the radiator. The dE detector was a 5-mm thick NE102A plastic scintillator. The distance between the sample and the phoswich detector was about 0.7 m.

The emitted neutron energy is almost equal to the energy of recoil proton when the recoil proton is produced by elastic scattering. The neutron energy spectra were unfolded by the FERDO code. The response function of detector system was measured by use of continuous-energy neutrons at WNR facility. We compared the experimental cross section data with the calculations by the Particle and Heavy Ion Trasnport code System (PHITS) and JAERI version of Quantum Molecular Dynamics (JQMD) codes in order to check the applicability of this experimental technique.

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